Topographic Development History of the Alaska Range

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Abstract: The overall goal of this project is to use variations in sediment source through time as a proxy for deciphering the uplift history of the Alaska Range (Fig. 1). In particular, we plan to track variations in sediment provenance through time for the Oligocene to present Tanana Basin. The main possible sediment source regions are north of the Alaska Range, south of the Alaska Range, and from the Alaska Range itself (Fig. 2). Furthermore, we will use the sediment source interpretation to test the hypothesis that the Nenana River changed direction during the Miocene (23 Ma to 5.3 Ma).

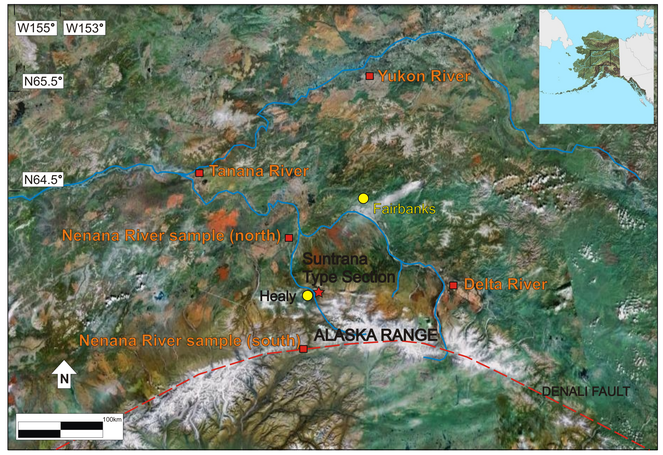

Figure 1. Regional Map with study area, bedrock, and modern river sample locations annotated. We sampled the uplifted Paleo-Tanana basin at the Suntrana Type Section.

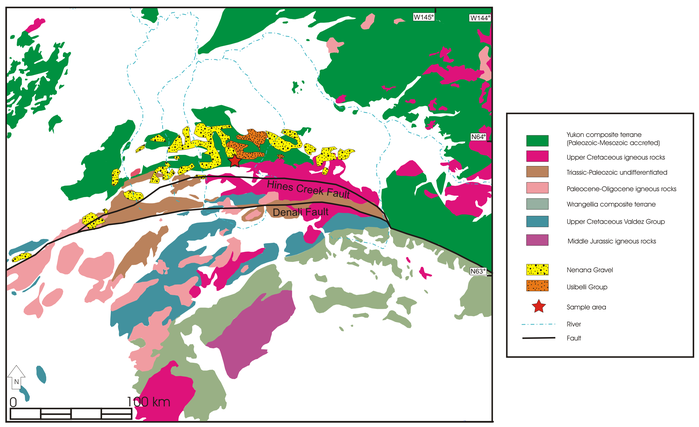

Figure 2. Geological Map. The 201 Ma to 153 Ma Talkeetna Arc lies south of the Alaska Range; Precambrian aged sources lie north of the Alaska Range. The plutons within the Alaska Range range from ~110 to ~40 Ma. Map modified from Trop and Ridgway, 2007.

Alaska Range: When did these mountains arise to become sediment source topographic highs and change drainage patterns?

Methods Planned: Our plan was to collect sandstone and sand samples from the Usibelli Group and Nenana Gravels at the Healy Creek site. We planned on separating out ~100 grains of muscovite from each sample and applying $^{40}Ar/^{39}Ar$ geochronology to deconvolve their original source. We also intended to collect volcanic ash samples (tephras) from both the Grubstake and Upper Suntrana formations in the Usibelli Group. Using Uranium-Lead (U-Pb) methods to date these tephras would give us better chronological control on the stratigraphy of the Suntrana Type Section. Our plan was to compare and contrast our muscovite age results with those of Brennan, who did a similar study using detrital zircon U-Pb dating on samples from the Suntrana Type Section.

Heavy mineral zircon U-Pb ages more often reflect magmatic ages, whereas light mineral muscovite $^{40}Ar/^{39}Ar$ ages more often reflect metamorphic ages. By integrating results from both these mineral-geochronological pairings, we can better reconstruct the uplift history of the Alaska Range.

For our purposes, muscovite was the mineral of choice because of its stability during transportation and deposition, low specific density, and because the potential source regions have bedrock lithologies that are abundant in muscovite with distinct age populations both north and south of the Alaska Range.

Methods Executed: We collected sandstone and sand samples from the Usibelli Group and Nenana Gravels at the Healy Creek site. In addition, we collected sand from the modern Nenana River both north and south of the Range. We separated out ~100 grains of muscovite from each sample. However, we were unable to use $^{40}Ar/^{39}Ar$ geochronology to date the muscovite grains due to technical difficulties with a broken custom valve in the University of Alaska Fairbanks Geochronology Mass Spectrometer. The tephras we collected from the Grubstake and Upper Suntrana Formations that we intended to use for absolute radiometric age control were not volcanic ashes in actuality. Instead, we applied U-Pb geochronology to date the zircon minerals contained in these samples to use for additional controls on sediment provenance through time.

Figure 3. Normalized probability density plots for detrital U-Pb zircon age data. Data is from the Usibelli Group and Nenana Gravel samples of Brennan and this study from Healy Creek (Fig. 4).
A probability density plot is a histogram that takes into account error. The yellow box illustrates the range for the Talkeetna Arc sources (201-153 Ma), the purple box illustrates sources from within the Alaska Range (~110-40 Ma), and the teal box illustrates Precambrian ages (4000-541 Ma). Data modified from Brennan, 2012.

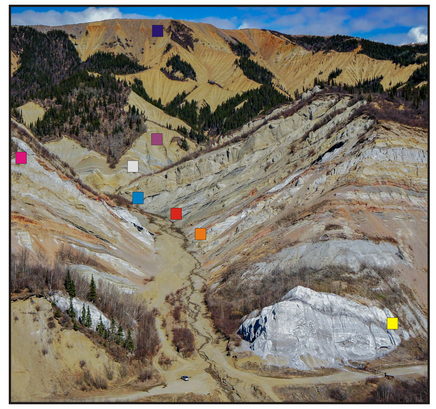

Figure 4. Photograph of the upper part of the Usibelli Group at the Suntrana Type Section. Samples were collected from Healy Creek, Suntrana, Lignite Creek, and Grubstake Formations and the Nenana Gravels. Our Healy Creek, Lignite Creek and Nenana Gravel samples are from similar locations, but not on the figure. Note the car for scale in the lower center of the photo. Photo and text modified from Wartes et al., 2013.

Conclusions: Our U-Pb zircon age results (Fig. 4) from the Grubstake Formation and Suntrana Formation is in general agreement with the results of Brennan (2012). Brennan's main conclusion was there was a change of sediment source for the Tanana Basin during the Early-Middle Miocene (~15 Ma). This is based on the large number of Precambrian grains in the Healy Creek and Lower Suntrana section indicating a mainly northward source for sediment. Whereas the Upper Suntrana, Lignite, and Nenana Gravel samples indicate less of a northward source (less Precambrian aged grains) and more of a southernly source (Talkeetna Arc aged grains, 201-153 Ma) and within the Alaska Range source (110-55 Ma). We also see a similar pattern in our aged zircon grains in our Upper Suntrana and Grubstake samples. Brennan concludes that during this time period (Early-Late Miocene), the Alaska Range was high enough in the region of modern day Healy to be a dominant source for sediment and to change drainage patterns. In juxtaposing the two separate data sets, we were able to solidify Brennan's conclusion that the east-Central Alaska Range began being uplifted during the Early-Middle Miocene when the Nenana River likely changed its direction of flow.

Continued Work: To further expand this research project, we can now apply the same approach to our muscovite ages once the Mass Spectrometer is fixed.

By doing so, we can compare muscovite results with our current data and the data of Brennan to further test the U-Pb zircon findings.

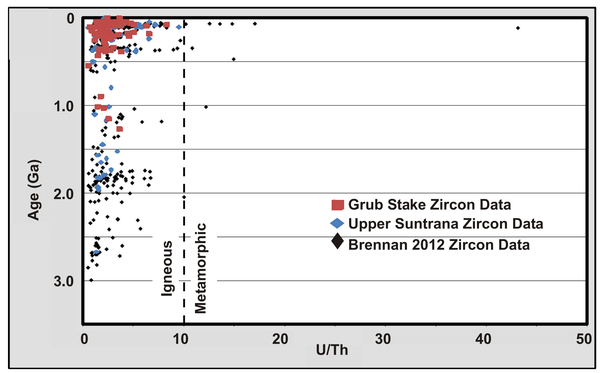

Figure 5. Uranium-thorium ratio versus age for all of Brennan's 2012 Usibelli Group and Nenana Gravel dated zircons and our new Upper Suntrana Formation and Grubstake formation dated zircons. A U/Th ratio >10 indicates that the zircon may have a metamorphic origin. The majority of the zircons dated likely have an igneous origin (U/Th <10). We are excited to see the results from the $^{40}Ar/^{39}Ar$ detrital muscovite analysis from our Usibelli Group and Nenana Gravel samples because muscovite is more representative of metamorphic bedrock. Muscovite is also a lighter mineral so because of its different transportability characteristics and different bedrock source, the data will be a way to confirm the results of the U-Pb zircon analysis. Modified from Brennan, 2012.

Brennan, Patrick R.K. "Lithospheric Structure and Geologic Development of a Collisional Orogen: Insights from the Central Alaska Range." (2012): 171-218. Print.
Trop, Jeffrey M., And Kenneth D. Ridgway. "Mesozoic and Cenozoic Tectonic Growth of Southern Alaska: A Sedimentary Basin Perspective." (2007): 57-58. Print
Wartes, Marwan A., Robert J. Gillis, Trystan M. Herriott, Richard G. Stanley, Kenneth P. Helmold, C. Shaun Peterson, and Jeffrey A. Benowitz. "Summary of 2012 Reconnaissance Field Studies Related to the Petroleum Geology of the Nenana Basin, Interior Alaska." (2012): 8. Print.

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